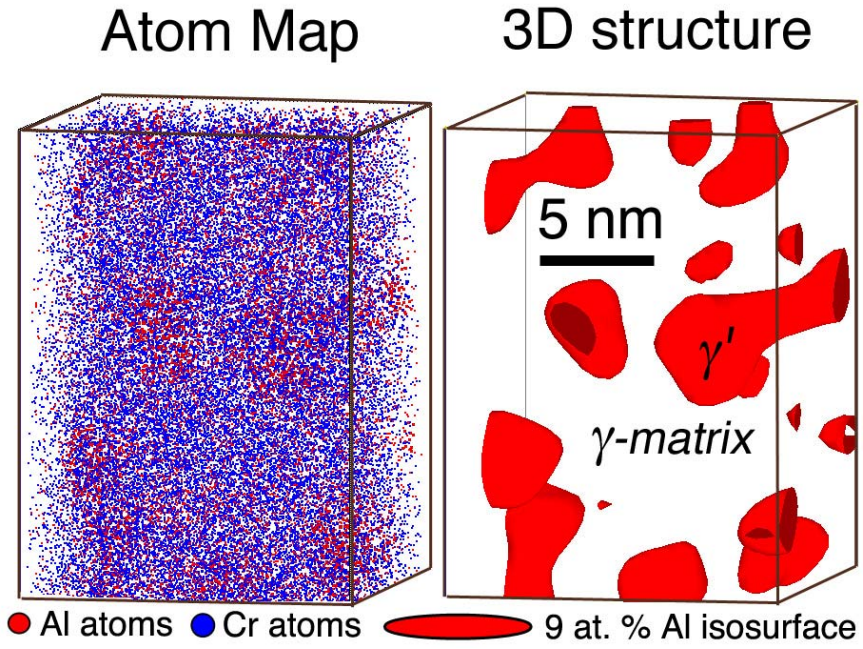
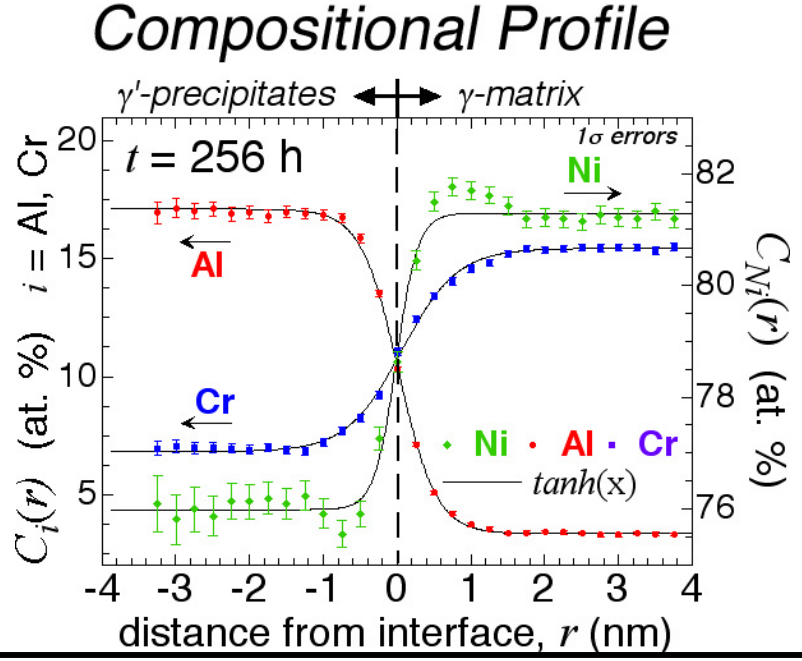
Temporal Evolution of the Nanostructure in Model Nickel-based Superalloys

Professor David N. Seidman
Northwestern University, DMR Award# 0241928





- With subnanoscale resolution on an atom-by-atom basis, aluminum (Al) rich and chromium (Cr) rich regions are clearly visualized in the 3D atom map
- The nanometer-sized γ'-precipitates resolved in three-dimensions have complex morphologies

- Multi-component composition profile at 0.25 nm interval distances has high sensitivity to small deviations
- Nickel (Ni) profile is the steepest (0.6 nm), while Cr is the most diffuse (1.7 nm). "Bump" in Ni at 1 nm reflects an excess above plateau concentration

GOAL: Structural and compositional evolution of the γ'-precipitation

The effects of Re on the temporal evolution of a Ni-Cr-Al-Re alloy

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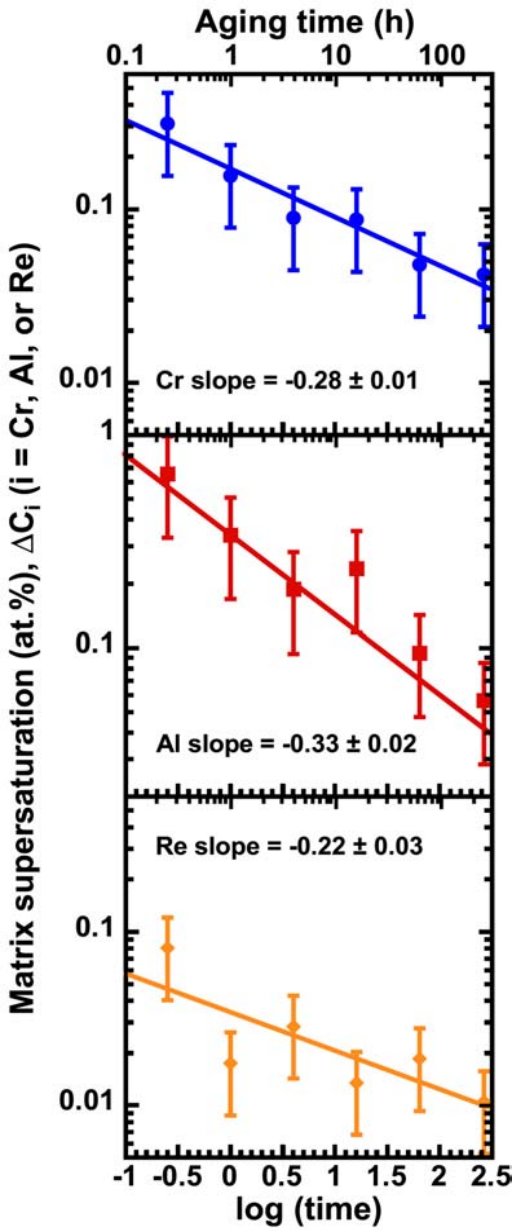
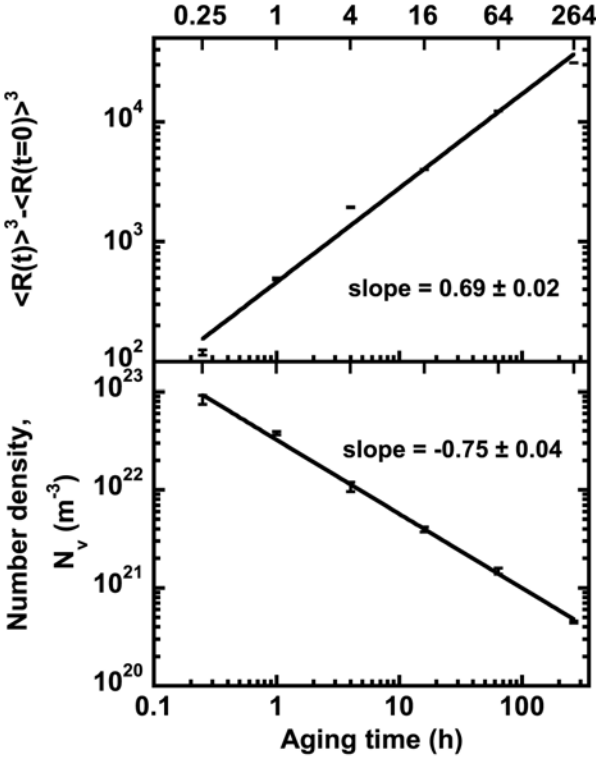
- **Addition of Re is expected to improve high-temperature creep resistance.**
- **Coarsening kinetics of γ′-precipitates is investigated employing TEM and 3DAP micoscopies.**
- **Addition of Re in Ni-Cr-Al alloy delays the coarsening of the precipitates and stabilizes the spheroidal morphology.**



Matrix supersaturations of Cr, Al, and Re as a function of aging time. Due to its fast diffusivity in Ni matrix, Al reaches equilibrium first. Therefore, only the time exponent of Al is in good agreement with coarsening theory, -1/3.

Temporal evolution of mean radius cubed, $\langle R \rangle^3$, and number density, N_v, of precipitates. Time exponents are deviated from coarsening theory (1/3 and –1, respectively), due to the coagulation and coalescence of precipitates.



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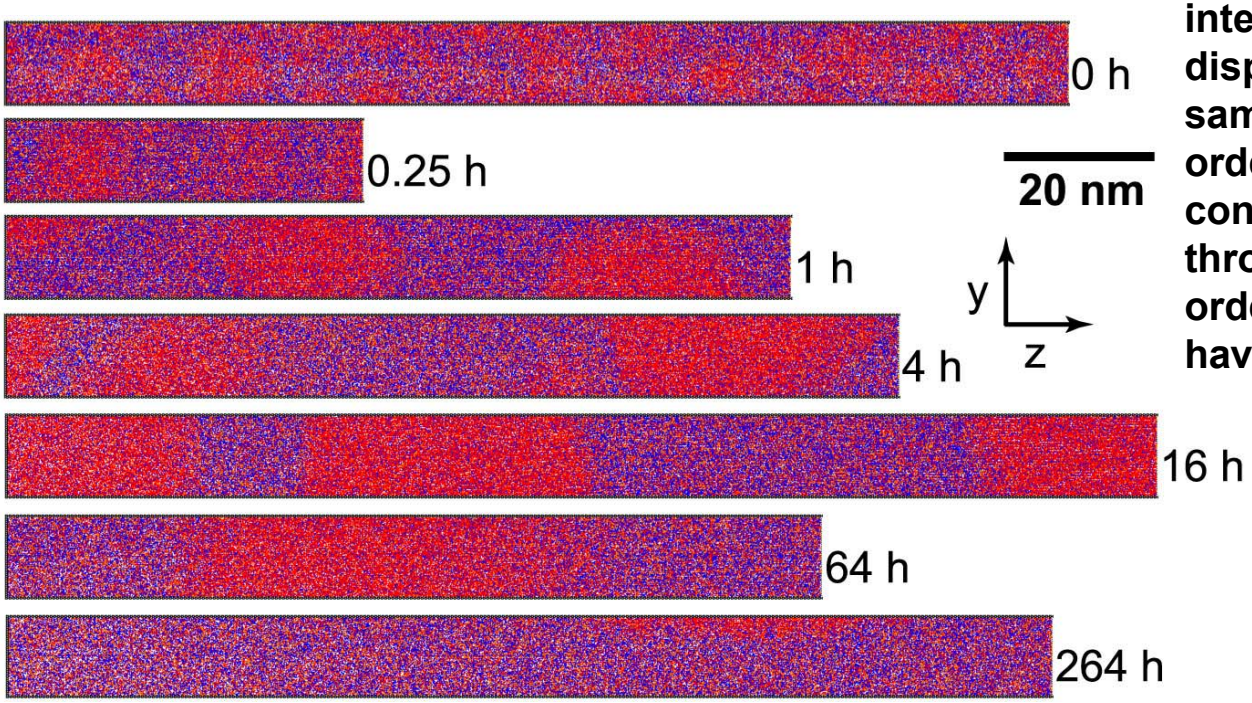
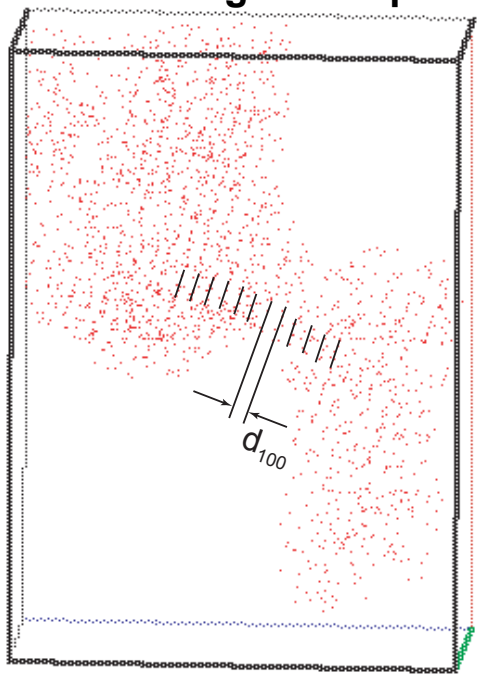


Three-dimensional reconstructions of Ni-Cr-Al-Re alloy illustrate the temporal evolution of γ'-precipitates. As aging time increases, the mean radius of precipitates increases, while the number density decreases. Cr atoms are in blue, Al atoms in red, and Re atoms in orange. Ni atoms are not shown for the sake of clarity.

Al atoms, inside the γ'-precipitates interconnected by a neck, are displayed in the as-quenched sample. This demonstrates that the ordering in one precipitate is continuous to another precipitate through neck. This suggests that ordering and phase separation may have occurred during water quench.



d_{100} = 0.3561 nm